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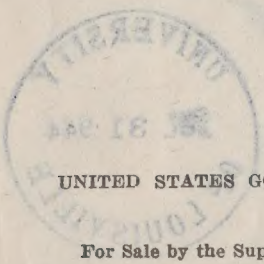

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THE BEDBUG—ITS HABITS AND LIFE HISTORY, AND METHODS OF CONTROL

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The common bedbug, *Cimex lectularius*, is a frequent household pest in the United States and other parts of the temperate zone. A close relative, *Cimex hemipterus*, is found in many tropical countries. The bedbug has a number of common names including such terms as the "chinch," "red coat," and "mahogany flat." The bugs present a varied appearance because of different amounts of blood which they may contain at any one time, and because of this variance it is believed by some that more than one species is found in this country. However, only a single species habitually attacks man in the United States.

The role of the bedbug in the transmission of disease has been the subject of considerable investigation. The infection of bugs with the causative agent of a number of diseases has been reported and in the case of some of these diseases evidence of transmission to laboratory animals has been obtained. Included in the diseases in one or the other of these categories are anthrax, plague, tularemia, lymphocytic choriomeningitis, yellow fever, European and African relapsing fevers, endemic or murine typhus, epidemic spirochetosis of Brazzaville, Minas Geraes spotted fever, leishmaniasis, and American trypanosomiasis. In spite of all this evidence, it seems probable that the bedbug plays only an insignificant part in the carriage of disease to man. However, eradication from the household is a desirable goal because of other factors such as the irritation caused by the bites, the disagreeable odor emanating from the bugs, and the esthetic objections to the staining of bed linen and other objects by the feces and by blood from the crushed insects.

GENERAL DESCRIPTION

The adult bedbug (fig. 1) is a flat, oval insect, measuring approximately $\frac{1}{5}$ inch in length and about $\frac{1}{8}$ inch in breadth. The body is covered with microscopic hairs. The bugs are usually of a rusty red or mahogany color but become a brighter red after feeding. In a starved condition the bugs are paper thin but after feeding become plump and elongated. The body of the engorged insect presents a banded appearance due to the hairless areas between the segments.

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The head is short and broad and is provided with a pair of compound eyes, between which are the two antennae, each consisting of four segments. The first segment is relatively short and thick and does not extend beyond the front of the head; the second segment is longer and thinner; while the third and fourth are characterized by increasing slenderness. Beneath the head is situated the jointed beak or proboscis, which passes backward between the first pair of legs. The beak consists of two pairs of stylets which afford apparatus for the piercing of the skin of the victim and the conveyance of blood to the stomach of the insect. The outer pair of stylets corresponds to the mandibles in other insects and is provided with barbs which exert a sawing action; the inner pair, which corresponds to the maxillae, forms two tubes, one for sucking up the blood and a second which functions as a channel for the injection of the saliva into the wound.

The thorax is situated immediately posterior to the head and consists of three segments which bear the three pairs of legs. The first segment, or prothorax, is relatively large, and extends forward on either side of the head. The small, triangular scutellum represents the visible portion of the second segment, or mesothorax. The third segment, or metathorax, is largely hidden from view from above by two small pads which are the rudimentary forewings.

The abdomen extends backward from the thorax and is marked by nine segments, although the first has been so reduced in size as to be inconspicuous. In the male, the abdomen is somewhat narrow and pointed, and the projecting terminal segment bears a clasping organ. In the female, the abdomen is broader and more bluntly rounded. There is a small nick-like cleft at the posterior margin of the fourth apparent abdominal segment which marks the opening of the copulatory pouch.

RELATED SPECIES OF BUGS

A number of species of bugs feed on plant juices and are occasionally mistaken for the bedbug. In parts of the West it is the belief that bedbugs can live for long periods in logs or dead trees; however, in this instance the bedbug has been confused with another insect, *Aradus* sp., which subsists entirely on plant material.

In addition to the two species of *Cimex* which regularly feed on man, a related bug, *Leptocimex boueti*, attacks man in New Guinea. The bat bug, *Cimex pilosellus*, at times becomes a household pest in this country, particularly in summer cabins which are left unoccupied during the winter months. In a similar way, some species of bugs infesting birds may sometimes invade houses. Among these species are *C. columbarius*, normally found in poultry houses and dovecotes; *Haematosiphon inodorus*, a parasite of poultry in Mexico and the southwestern United States; and *Oeciacus vicarius* which is found in

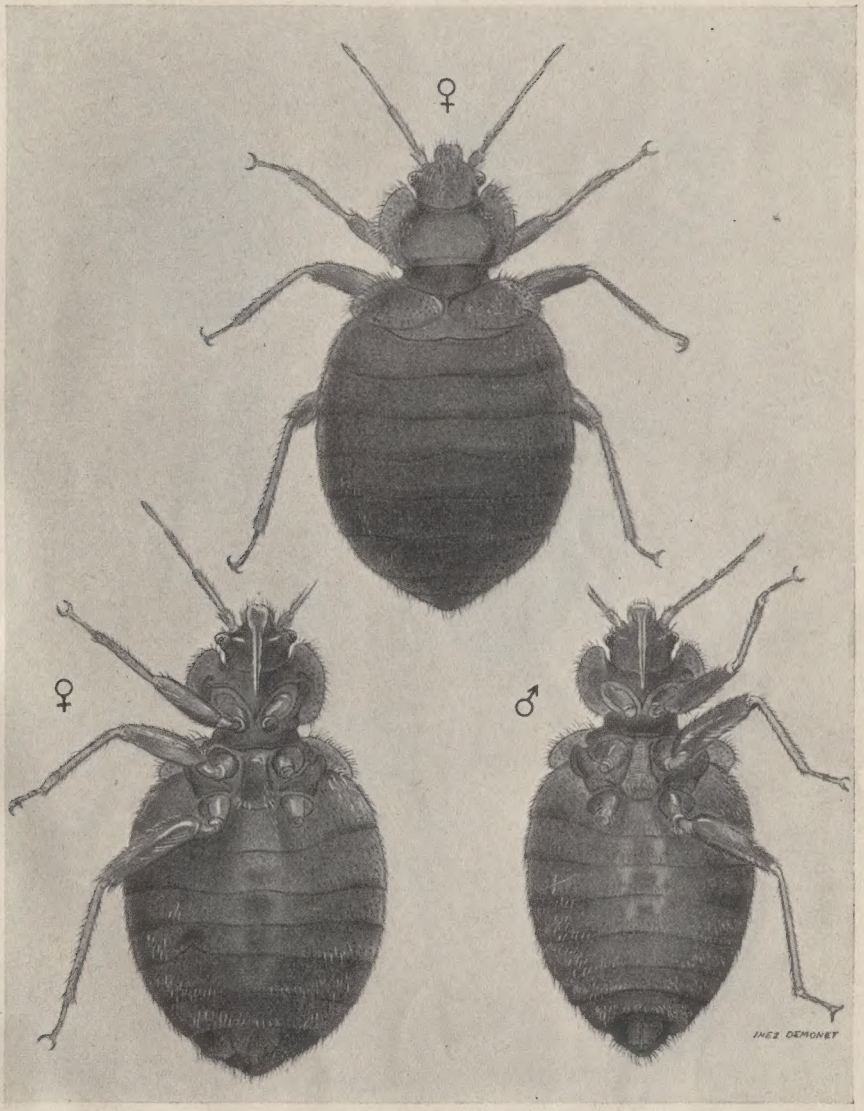

FIGURE 1.—The bedbug, *Cimex lectularius*. ♀ (female, partially engorged), dorsal and ventral views, ♂ (male), ventral view. Greatly enlarged.

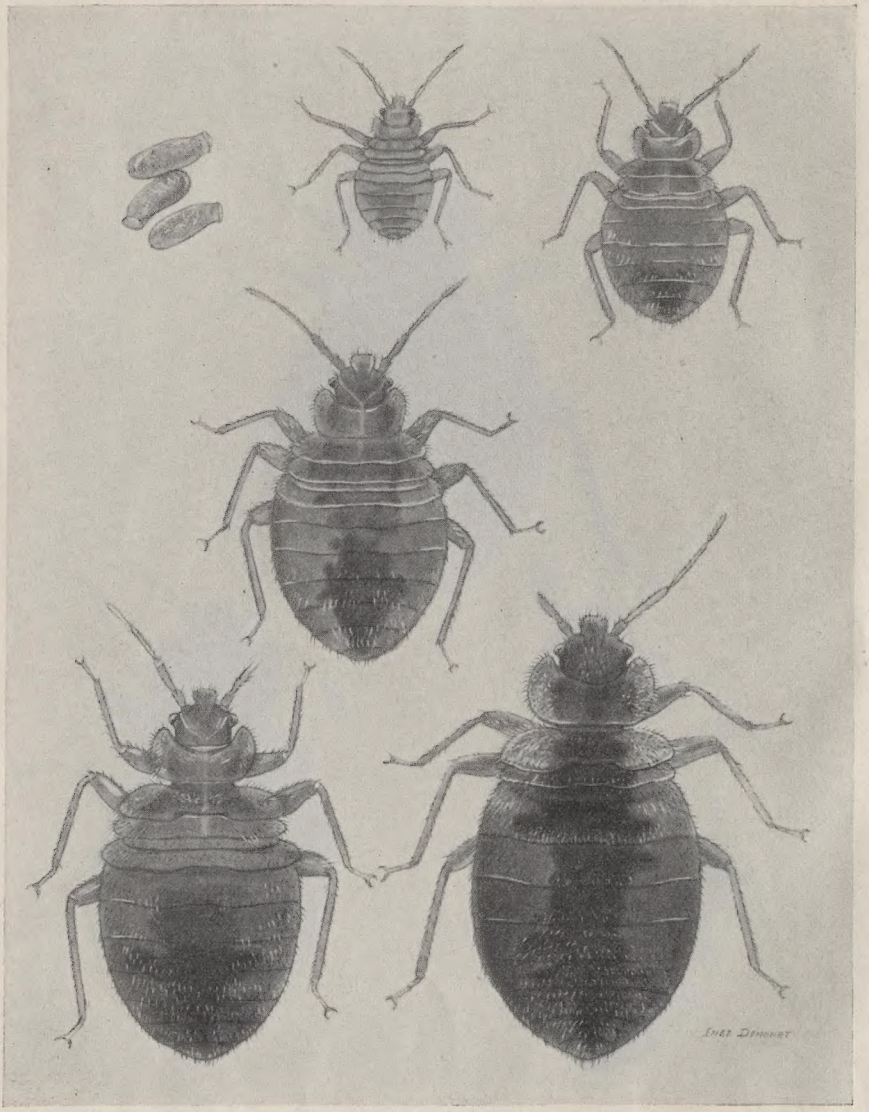

FIGURE 2.—The bedbug. *Cimex lectularius*. Eggs (upper left), larva, and 4 nymphs. Greatly enlarged.

the nests of swallows. All of these species occasionally feed on human beings.

HABITS

Bedbugs are sucking insects and obtain blood from the host through the elongated beak or proboscis. Man is the preferred host but the bugs will feed and continue their life cycle when restricted to the blood of other animals, including poultry, mice, rats, guinea pigs, canaries, etc. At times, pet animals in heavily infested houses may be attacked to the extent that they become weak and anemic from the loss of blood.

The bugs usually feed at night but under certain circumstances may emerge and bite during the day. Particularly is this true when they infest theater seats, the furniture of rest rooms, office chairs and desks, and other equipment not usually in use during the night hours. During the daylight hours, the bugs commonly take refuge in protected cracks and crevices. They frequently infest bedsteads, particularly the wooden variety, mattresses, springs, and the upholstery of chairs, couches, and settees. In the structure of the house itself, they may be found behind torn or loose wallpaper and picture frames, under the baseboard or wainscoting, between or under floor boards, especially if the floors are covered by rugs or carpet, in the molding around the doors and windows, behind the openings of water or steam pipes, and in any other location which provides darkness and isolation.

In the biting process, the bedbug injects into the skin of the host a fluid which probably helps to prevent clotting of the blood during the act of feeding. It usually requires 3 to 5 minutes for the bugs to obtain a full meal. The irritation which follows the bite varies considerably in different individuals. Some persons seem to be quite insensitive in this respect. However, others suffer marked reactions with redness, swelling, and persistent itching at the site of the bite. Such persons find it impossible to obtain adequate sleep under the attacks of the bugs. If relief is not obtained, the situation may react on the general health of the individual.

The disagreeable odor associated with the bedbug is due to an oily liquid which is secreted by two scent glands which have their openings on the lower surface of the middle thoracic segment. Similar glands are found in most of the group of insects comprising the true bugs.

LIFE HISTORY

The bedbug undergoes an incomplete metamorphosis, the young larval bug resembling the adult in form, structure, and habit, in contrast to such insects as flies and moths which undergo a complete metamorphosis, or change of form, from the larva through the pupa or chrysalis

to the winged adult. The changes in the bedbug during its life history are externally marked mainly by an increase in size.

The eggs (fig. 2) of the bedbug are elongated, pearly white objects measuring about $\frac{1}{25}$ inch in length and provided at one end with a collar and lid which is pushed outward when the larva hatches. When deposited, the egg contains an embryo already in a high state of development. These eggs are laid mostly on rough surfaces, in cracks and crevices behind woodwork or wallpaper, and in similar secluded areas. The eggs are fastened to the surface of the material by a quick drying cement secreted by the female bug.

When temperature and food conditions are favorable, the mature female bedbug lays on an average of 2 eggs per day. Under most favorable conditions, the total egg production may reach several hundred, although the average is probably less than 200. Relative humidity apparently has little effect on egg laying but temperature is an important factor. Eggs are seldom deposited when the temperature is below 48° F. and only very few are laid between 48° and 60° F. Provided the female bug has ample opportunity to feed, maximum egg production takes place between 70° and 82° F. Opportunities for regular feeding promote oviposition but starvation soon results in suspension of egg laying.

The rate of development of the eggs is extremely variable and depends on a number of factors. Eggs laid some time after a blood meal show more variations in hatching time than do those oviposited soon after the insect has fed. Under experimental conditions eggs did not hatch when kept at a temperature of 98.5° F. nor at temperatures below 55.5° F. At 70° F. hatching takes place in 6 to 17 days. At a temperature of 57° F., it may be delayed for as long as 30 to 40 days.

The newly hatched bug is translucent and almost colorless. These young bugs are unwilling to feed immediately after hatching but at ordinary room temperatures in heated homes usually take their first blood meal in 24 to 48 hours. At lower temperatures, this prefeeding period is prolonged. Following the initial blood meal, the young bugs go through five stages of development (fig. 2) before becoming adults, each stage being characterized by molting or shedding of the skin. After each molt a blood meal must be taken before the next stage can be attained. The shed skins of the various nymphal stages are thin, white, semitranslucent objects having the shape and form of the nymph. They may be found in areas frequented by the bugs.

After a full blood meal, the time required until molting depends on the temperature of the environment, the amount of blood ingested, the particular stage of development, and the amount of activity before feeding. As with the newly hatched bugs, some time elapses between molting and the subsequent feeding which prepares the insect for

the next developmental stage. Considering the whole elapsed time between hatching and the attainment of the adult stage, the total nymphal period may vary from 14 days at 82° F. to 118 days at 59° F. Assuming that adequate opportunities are available for feeding at will, full nymphal growth during the hotter parts of the summer in temperate latitudes probably requires 2 to 4 weeks, while the time from oviposition to oviposition is approximately 5 to 8 weeks. At temperatures maintained in centrally heated homes during the winter, these respective periods are approximately 4 to 9 weeks and 7 to 12 weeks. Consequently under favorable conditions there may be three or four, or even more, generations produced in the course of a year. Owing to variations in the period of development even in bugs hatched at the same time, the generations overlap so that all stages may be found at different times except perhaps in unheated rooms in which development is arrested during the winter months.

LENGTH OF LIFE

The longevity of the bedbug is extremely variable. The matter is of interest from the standpoint of survival of infestations in unoccupied houses and the ability of the insects to remain alive without food in places reached accidently and in which a blood meal is not available. Starvation and low temperatures contribute to the longevity of the bugs since both factors reduce activity to a low level and force the bugs into a state of semihibernation.

There is some variation in survival of different forms. If a house has remained unoccupied for a long time, fifth instars and adults, particularly unmated females, would be the predominant forms in the surviving population. Under experimental conditions, unmated female bugs have survived for 550 days when kept without food at a constant temperature of 44.6° F. and a relative humidity of 90 percent. Survival under such conditions is correlated with relative humidity since water loss contributes to decrease in longevity. Likewise higher temperatures shorten life under starvation conditions. For instance, at 90-percent relative humidity unmated females survived for a maximum of only 181 days at a constant temperature of 73.4° F. At 72.5° F. and 75-percent relative humidity fifth instars have lived for 179 days. With normal feeding and reproductive cycles, individual bugs have survived for 316 days. Adults of certain strains kept under conditions of a constant temperature of 64.4° F. and 90-percent relative humidity have shown survival rates of around 40 percent after 25 weeks. While various external conditions and individual differences influence length of life, it may be seen that the bedbug in general is a very hardy creature, a fact which renders control a difficult procedure for the average householder.

From a practical point of view, it is probable that bedbugs are capable of surviving over winter in unheated buildings. Mature and partly mature bugs can survive freezing temperatures for a considerable period. The eggs and newly hatched larvae succumb to temperatures below freezing for 15 to 30 days. However, bedbugs are relatively more susceptible to heat than to cold. At 113° F. eggs are killed after an exposure of 1 hour and first stage nymphs after 15 minutes. The thermal death point of the adult bugs is about 1.8° F. below that for the eggs. Humidity is said to have little relation to the influence of heat at these high temperatures.

MODE OF DISSEMINATION

It is the belief on the part of some that bedbugs are associated only with filth and can flourish only in unclean surroundings. Unfortunately, such is not always the case since the bugs can and do find their way into high-class homes and apartment houses. It is probable that the bedbug is spread mostly through human agencies as the bugs themselves do not tend to migrate extensively. However, in row houses and apartments they may spread from one family unit to another especially if opportunities for feeding are limited in any one location.

Bugs are frequently introduced in the clothing or in the baggage of travelers. Sometimes the purchase of second-hand furniture provides the way for infestation of the home. Laundry done in private homes in which bedbugs are prevalent may be the means of carriage of the bugs to other locations. Furniture vans may provide opportunities for infestation.

METHODS OF CONTROL

Unless fumigation with suitable chemicals can be resorted to, the control of bedbugs requires constant persistence and a considerable amount of hard work on the part of the householder. Initial infestations can frequently be overcome by attacking the problem vigorously on the discovery of the bugs. When first established, the bugs will be found mostly on the mattresses and in the cracks and crevices of the beds. Later, they tend to migrate to the other furniture and then to scatter and take refuge in cracks in the walls, behind baseboards, window and door casings, picture moldings, and other locations. The use of wallboard or sheathing affords excellent harborage for the bugs since the unions of the sections frequently do not fit tightly and thus provide cracks in which the bugs can hide.

Sprays and hand applications.—The use of some of the fly sprays which are readily available at retail stores is of some value in the control of bedbugs. These sprays consist of high grade, water white

kerosene, practically stainless, with which are combined certain basic insecticide materials. Before the war, many of these sprays contained pyrethrum extract but owing to military requirements this insecticide has largely disappeared from the market. However, there are still available sprays having as an active ingredient organic thiocyanates; a 3-percent solution of the active ingredient has been found of value against bedbugs. These fly sprays are most effective when they can be brought into actual contact with the eggs or the bugs. They may be employed in the ordinary hand spray gun, although they are much more effective when sprayed from a power-driven apparatus which forces the insecticide better into the cracks and crevices in which the bugs hide. Most professional insect exterminators are equipped with the proper type of apparatus to apply these liquid insecticides to best advantage. In using thiocyanate sprays, it is advisable to close off the room for an hour or so and then thoroughly air it before reoccupancy. Heavy spraying should not be carried out in the presence of open lights or fires.

Because of the demand for better insecticides for military use, new and more powerful compounds have been developed. After the termination of hostilities, these compounds will no doubt be made available for distribution through retail outlets; at the present time, however, they have not been released for civilian use.

When suitable equipment for the application of sprays is not available, the hand application of liquids can be employed. A small brush can be used to apply turpentine, gasoline, kerosene, or benzene to cracks and crevices in which the bugs may hide. This method of treatment can be used advantageously on bedsteads, springs, and mattresses, and much can be accomplished in the control of bugs, particularly if the problem is attacked before the pests get into places of concealment other than the furniture. *However, care should be taken in the use of the above-mentioned inflammable liquids. The windows should be kept open and fires and open lights extinguished until the fumes have escaped.* Another liquid insecticide which can be readily obtained and applied by the householder consists of 1 ounce of bichloride of mercury dissolved in 1 pint of alcohol, to which are added 4 ounces of turpentine.[1] *Bichloride of mercury is a very poisonous substance. The solution should be kept where children cannot have access to it and should not be used on surfaces which might be chewed or licked by young children or pet animals.*

In employing sprays or hand applications for the control of bedbugs the householder should realize that persistent effort is needed if success is to be obtained. Treatments should be applied every 10 days, or more frequently in event that bugs are detected between treatments.

[1] Leaflet No. 146, U. S. Department of Agriculture.

Fumigation.—In cases in which bedbug infestations have become firmly established in dwellings and other buildings, the average individual will find it difficult, if not impossible, to eradicate the bugs through the use of fly sprays or hand application of insecticides. This applies particularly to older houses in which plaster cracks and shrinking of the woodwork provide ideal harborage for the bugs. In cases in which the individual householder finds that the infestation is maintained in spite of all efforts to eradicate it, it is advisable to employ fumigation.

Effective fumigation provides access of the insecticide to eggs, intermediate forms, and adult bugs in cracks, crevices, and other places which cannot be reached by liquid insecticides. Unless there is too much leakage of gas, a single fumigation can be expected to destroy all forms of the bedbug. Buildings should be thoroughly sealed before fumigation is attempted.

Sulfur dioxide has long been employed for the fumigation of houses in bug control. The burning of 2 to 4 pounds of sulfur for each 1,000 cubic feet of space with exposure of 10 to 24 hours is recommended. This method can be carried out by almost anyone if proper care is used to prevent fires by placing the sulfur in a pan in a tub of water. However, results are frequently not satisfactory since the sulfur fumes may fail to kill all eggs and young bugs, in which event the infestation will return. Furthermore, sulfur fumes will tarnish metals and are apt to bleach delicate colors in fabrics and wallpapers.

Hydrocyanic acid gas is probably the most effective fumigant for the destruction of bedbugs. However, the gas is extremely toxic and only slight concentrations are necessary to cause death of man and lower animals. For this reason, the material can be used with safety only in detached homes which can be vacated during fumigation. *For the reason that hydrocyanic acid gas is so deadly, it should be used only by persons fully informed concerning the methods of its application and the hazards involved.* It should be applied only by professional exterminators or fumigators approved by the local health department or other authority.

Certain other gases have been used to advantage in the fumigation of buildings for the eradication of bedbugs. Among the most effective of these gases are methyl bromide and chloropicrin. While not as poisonous as hydrocyanic acid gas, they are sufficiently toxic that they must be employed with considerable care and should be used only by persons who are entirely familiar with their mode of action and the precautions to be taken. However, in the hands of experienced fumigators, methyl bromide and some other compounds can be employed with safety in eradicating bugs in single rooms or apartments. In this they possess an advantage over hydrocyanic acid gas which can be used with safety only in evacuated buildings.

In England, heavy naphtha has been used successfully for the fumigation of dwellings. The gaseous fumes of this coal tar residue, like other fumigants, penetrate the hiding places of the bugs and are said to be effective in destroying all stages. This material is most effective when the building can be evacuated for 24 hours. The liquid naphtha is sprayed on screens of cotton cloth distributed throughout the dwelling. The temperature is maintained preferably at 75° F. to promote vaporization of the fumigant. Heavy naphtha is relatively nontoxic and can be used in row houses and flats without evacuating the entire building or the adjoining dwellings. However, when using this material, precautions should be taken against fire, and inhalation of the vapor should be obviated by the employment of masks. At this writing, this method of fumigation has not come into use in this country but experience in England has been very favorable. A domestic naphtha coming closest to British specifications is not available at the present time because of war demands.

In cases in which bedbug infestations are confined to upholstered furniture, it may be advisable to dispatch such furniture to a reliable storage warehouse for fumigation in a vault maintained for such purposes. This procedure is particularly advisable when moving infested household goods to a clean residence and can usually be depended upon to eradicate the infestation and prevent its carry-over to the new home. In small towns or in communities in which such services are not available, it is advisable to move the furniture to the porch or to outbuildings and to go over it thoroughly with gasoline or one of the other remedies recommended for hand application before moving it to the new dwelling.

Superheating.—One other method of attack is available against the bedbug and this consists in raising the temperature within the infested building and maintaining it at a high level until all bugs are killed. Since eggs and intermediate stages are killed at a temperature of 113° F. and adult bugs at a slightly lower temperature, the heating of rooms or buildings to 120° to 125° F. for several hours will eradicate infestations. The method is particularly applicable during the summer months when the central heating plant can be employed without difficulty in maintaining the necessary temperature. It is well to check on the degree of heat by placing thermometers in parts of the house which would ordinarily have the lowest temperature. Failures may occasionally occur in loosely constructed frame dwellings with considerable heat loss. Ordinarily little damage results to furnishings by the use of this method but it is advisable to remove delicate musical instruments or lightly veneered pieces of furniture before superheating.

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